sun being magnified to five inches in diameter. Even with the 12-inch refractor the occasions suitable for a critical examination are rare.

In front of the slit I also brought the terminals of the secondary circuit of an induction coil, which were connected with a Leyden battery. The current through the primary wire of the Ruhmkorff was furnished by a Gramme machine. This arrangement permitted the production of a strong oxygen spectrum near the spectrum of the sun's limb.

The most obvious point to determine was whether the oxygen lines visible in the spectrum of the solar disc projected beyond the apparent limb of the sun as seen in the spectroscope; in other words, whether oxygen could be detected in the lower parts of the chromosphere. For this purpose I looked particularly at the bases of the prominences. I saw a large number of reversed lines, including some of the more delicate lines of Young's preliminary catalogue, but on no occasion could I be sure that the oxygen lines were seen outside of the limb. Of course, unless such an observation could be made in a perfectly tranquil atmosphere, certainty could not be attained. The experiments were terminated temporarily on account of getting my right arm caught in the engine, but they will probably be resumed next summer.

On examining Prof. Young's catalogue of chromosphere lines made at Sherman Station, in the Rocky Mountains, it appears that he does not note the great oxygen group near G, and as his observations were made with remarkable accuracy and care, this would tend to corroborate the view that the bright-line spectrum of oxygen as seen on the sun's disc must have its upper limit close to the apparent spectroscopic limb of the sun.

HENRY DRAPER

Observatory, Hastings-on-Hudson, New York, January 28

Brain of a Fossil Mammal

IN NATURE (vol. xvii. p. 222) is an account of some remarkable characters of the brain of *Coryphodon*, as determined by Prof. Cope, and recently published in the *Proceedings* of the American Philosophical Society, vol. xvi. It may interest some of the readers of NATURE to know that the subject had been previously investigated by the writer, who published a description and figures of the brain cast of *Coryphodon* in the *American Journal of Science*, vol. xi. p. 427, May, 1876, more than a year before the article above quoted appeared. Prof. Cope made no reference to my paper, although perfectly familiar with it. His figures moreover do not represent, even approximately, the brain of *Coryphodon*, owing to serious errors in his observations, which were based upon an imperfect specimen, as I have shown elsewhere (*American Journal of Science*, vol. xiv. p. 83). One of the most glaring of these errors is seen in the supposed olfactory lobes which, as figured, include no small part of the nasal cavities, and naturally add a very remarkable feature to this brain cast. The specimens from which my figures and description were taken are in excellent preservation, and are in the Yale College Museum, where they have been examined by Prof. Huxley and many other anatomists.

The attention called by NATURE to this paper of Prof. Cope's makes the present correction seem necessary for English readers, especially as the paper quoted is a typical one, illustrating the methods and work of its author. O. C. MARSH

Yale College, New Haven, Conn., February 7

Origin of Tracheæ in Arthropoda

IN NATURE (vol. xvii. p. 284) is a notice of a work by Dr. Palmen, of Helsingfors, on the morphology of the tracheal system. From the wording of the notice it appears as if the views of Dr. Palmen as to the origin of tracheæ from skin-glands, and as to the importance of Peripatus as an ancestral form of the Tracheata, were new to science. I was, to the best of my belief, the first to discover that Peripatus was provided with tracheæ; and in a paper on the structure and development of *Peripatus capensis*, published in the *Phil. Trans.* for 1874, I discussed the question of the origin of tracheæ, and put forward exactly similar views to those cited in your notice. These views have been adopted by Prof. Gegenbaur in his new edition of his "Grundriss der Vergleichenden Anatomie" (1878), in so far at least as that Peripatus is placed in a separate division of the Arthropoda, "the Protracheata." Haeckel, following Gegenbaur, supposed his Protracheata to have been provided with tracheal gills, but the diffuse arrangement of the tracheæ in Peripatus led me to conclude that the ancestral tracheata were terrestrial, and not aquatic, in habit, and that tracheal gills were comparatively late developments.

I am very glad to find that Dr. Palmen has arrived at similar results. Unfortunately, the place of publication of his treatise is omitted from your notice. It would be of value if you saw fit to append the reference as a note to the present letter.

Exeter College, Oxford H. N. MOSELEY

[Dr. Palmen's paper was published in Helsingfors.—ED.]

The "Phantom" Force[1]

III.

WHILE very clearly establishing that it is to the force urging a body that the potential energy which the body *has not*, but can have, must properly be assigned, and calling it very appropriately the "energy of tension,"[2] a very apposite remark (which I do not remember to have met with before) is added by "X" in his concluding paragraphs. The body could not command this "force-work" in any position unless it had *been put* into the proper position to command it; and the *actual energy* spent in putting it there *is the* "energy of tension" which, although forfeited to the force, *it can* reclaim. In this view it is not surprising that potential energy should have the same terms for its measurement as actual energy, since it is nothing but the actual energy which the body, or some agent operating upon it, has really lost; and if we pass from permanent forces to those ephemeral ones which physical agents can produce on an already existing arrangement of bodies, then, according to the existing configuration of the bodies when the force is generated, and in proportion to the "potential," or to the available statical energy developed, so is the work of the agent used to bestow this energy. In these cases of temporary "potentials" the actions are not actions at a distance, but through an intermediate medium, it may be strung with motion, and with permanent forces, which have absorbed the work applied to put the intervening medium, as it were, on the stretch, and to develop the ephemeral energy of tension. But we recognise this very clearly (as for instance in charging well-insulated electrical conductors) only in the rare cases of reversible arrangements. The fatigue and exhaustion which we soon feel when holding out at arm's length a heavy weight (although we do no work upon the weight) arises, for example (like that of a galvanic battery exciting an electro-magnet and supporting a heavy armature), from two causes, the first of which, the excitation of the magnet and armature, and the tightening of the muscles, or producing the requisite statical energy for the occasion, absorb but a small portion of the work. The main expenditure is "frittered away" (a most expressive description of the process, which I owe to Prof. Tait) in aimless and random paths as heat, by the wasteful process of electrical or muscular currents afterwards kept up to maintain the excitation.

I have thus far sketched out a general view of physics (one which is perfectly adapted to satisfy its general requirements), in which self-balancing actions and reactions, only depending in intensity on the distance between their centres are supposed to be permanently implanted in pairs of material particles, a special case, or fresh assumption regarding the general system of forces contemplated in the Newtonian theory of mechanics, which either may, or may not be the complete theory of their action, but which assists the mind very greatly, by giving them a mechanical explanation, in forming true and correct preliminary notions of the two leading laws of the great modern science of energy. And here I may take the opportunity to mention that my own views of the relationship of modern physics in its various mutually dependent branches to that famous foundation of mechanics which Newton laid (or perhaps I should rather say, since the supremacy of mechanics is by no means yet conceded, of the Newtonian basis of mechanics to modern physics) have been mainly imparted and completed by a perusal of the excellent little manual on "Matter and Motion" by Prof. J. Clerk

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[1] Continued from p. 322.

[2] The term "statical energy" introduced by Sir W. Thomson (see a note in Prof. Tait's "Sketch of Thermodynamics," p. 52), and now proposed (NATURE, vol. xvi. p. 521) by "W. P. O." to be substituted for the above, is of all the phrases yet used to denote it, the truest and simplest description of its real character. That it appertains to the force and not to the body is apparent both from this name and from the definition (which I have endeavoured to illustrate) that it is the "work" of the "agent," a property or possession of *that individual*, equal and opposite to, but *not the same* as its "net," or effected work.

Maxwell, reviewed by Prof. Tait in NATURE (vol. xvi. p. 119), a very moderate acquaintance with which has sufficed to remove from my mind all the doubts and perplexities which, without such assistance, must beset every cultivator of physics and mechanics attempting to take a comprehensive view of these two parallel sciences in their close relations to each other. The latter science especially, mutilated and deformed, and roughly scattered up and down in fragments, as we commonly find it represented, wears in general in our crude brains and in ordinary practice very much the same dismembered aspect which physics in its numerous subordinate branches presents to those who devote their attention especially only to some particular one of its departments.

But the new and comprehensive science of energy has, besides, its own special debatable region, in much the same way that mechanics has, although of an entirely different description; and however cheerfully we might consent, by basing all the propositions of mechanics (a perfectly possible proceeding, as has here been indicated) upon a system of permanent and reciprocal force-pairs, to include among the vicissitudes of force-action, besides its own clearly distinguishable phenomena, also (with countless impenetrably hidden fields of operation) all the known agencies of its more versatile and less easily definable kindred science of energetics, yet it can scarcely be regarded as immediately desirable, in the absence of sufficiently abundant proof, to make this assumption; nor is it perhaps expedient, on the new account just mentioned, to take it too readily for granted as a sound and simple basis of the leading laws of the new science, until the field of phenomena which the latter are framed to include is itself so clearly defined and circumscribed, as not to offer in its own relations and conditions objections to the course which may seem to contain in them anything which may prove to be insuperable, or which might very quickly lead to its abandonment.

To assert the principle of virtual velocities concerning the agent force, although we can voluntarily enlist the action of this agent in mechanical combinations, does not necessarily compromise our free will in any way, because the manner of enlisting this servant of our will cannot be definitely, and in a scientific point of view completely specified as the necessary form which the exercise of volition must take; and accordingly no natural law which completely binds and describes any force, can possibly describe and define also, as completely, the volition which produces it. But even if the volition concerned in producing a force were, as a cause, completely definable, and if we may assume that pure inductive science is capable immediately of so describing it in part, and of ultimately (in its indefinitely achieved development) reaching no partial or imperfect view of every process of volition, so as to be able with assigned actions of will to construct a perfectly unerring plan of all the operations of a Providence subjected to these conditions, and to trace without a single fault or discontinuity the whole current of consequent events belonging to them, yet it is evident that the result would lack an element of genuineness, of whose absence we should immediately be conscious as rendering it an inadequate and unauthentic represesentation of the operations of that perfect will and of that Divine Omnipotence, to whose purposes we owe the obedience and the entire subserviency of our wills in all our actions. This moral obligation of our actions springs from a side of our natures *truly* unseen, but to which we owe dictates of our actions as quick and spontaneous as those which come endorsed with reason to us from our natural senses. On the other hand, to suppose that reason will ever bridge the gap which divides inanimate from living agency, and will be able to register perfectly on her tablets (in the way just now supposed) every event of volition, is as visionary as to suppose her capable of apprehending and of taking a measurable account of the purposes of those actions which we hold to be inspired. But in the part which reason plays as a faculty given to us for learning wisdom and for seeking after and cultivating virtue from our cradles, in all the vicissitudes of life, there appears to be no break or interruption to its ownward progress, though its goals may be partly invisible and partly unattainable; and "new forces" in nature must evidently lie abundantly along its path. The "forces" of living beings, in particular, are inscrutable to it, and those of humanity at least must especially be so, for two reasons, a *moral*, as well as a vital or organic one, both differently descriptive of the ultimate constitution of our free will. If, therefore, there appears no ground (as I believe that Hirn's, and perhaps other experiments, have shown) for introducing an exception of living agents in the law of conservation of energy, perhaps the progress of physiology and of biological physics may also show that to make the same exception in the law of dissipation, or of the loss of availability of energy in every action, is equally incapable of substantiation could we see those forms of energy which we, and other living beings, make use of in apparently transgressing the generality of this law by partially restoring their availability to some very obvious forms of energy.

In this view of infinite progress of investigation, energy must keep its form of energy of motion, or of such energy converted into work of "agents;" and from what has been above described, it is not necessary that the work of these agents should be the energy thus abandoned in *a new kinetic* form. All the actions of an agent *can be imagined* to be consequences of special kinds of motion, but of what advantage it may be *to suppose it*, when in the midst of conceptions so distractingly profound and unapproachable as encircle the new science of energy, an agent as simple and intelligible as mechanical force is presented to our understanding as an example of what an agent of will and purpose may perhaps be like, it is very difficult to reflect upon and comprehend.

At the outset of this long-since-begun, and now quite differently-concluded letter from what I contemplated, I proposed, in connection with Mr. Crookes' famous series of investigations (especially those last crowning points of his discoveries in which vacua so perfect were produced as fairly to eliminate the principal cause of rotation of the arms of a radiometer, originally recognised in the action of residual gas), to point out some means by which, in vacua so complete, the mode of action of force might possibly be elucidated by experiments. A beam of rays, bent and reflected, for example, so as to fall at grazing incidence from the right or left on a flat end, instead of on a vane of one of the arms of a very perfectly-exhausted radiometer, might be found to move it sensibly, and perhaps more distinctly, as the exhaustion reached its limit, in opposite directions corresponding to the directions from which the beam grazed the face, which it would be difficult to attribute to molecular impacts of the residual gas; and in the action of such an external, and to all ordinary perceptions quite uncounterpoised, force (supposing radiation really to produce it), a field of new discoveries relating to direct mechanical effects of the luminiferous ether would obviously present itself, which would be of the highest interest and consequence. But as regards the interpretation of any effects which might be observed, especially in connection with new views of the nature of potential energy which they might open out, I prefer now to refrain from offering any hints or suggestions, knowing that any inquiry which offers prospects of studying force under a new aspect, cannot be guided and directed beforehand, so as either to establish or confute any of the already well-proved laws of its action, but that in the broad principles which the science of energy presents for our consideration and development it could only be prosecuted as a new science, a new branch of general physics contributing something like its predecessors (heat, radiation, chemical action, electricity, &c., but *what* we should attempt in vain to picture to ourselves) in the capacious science of energy, as a new ascent towards that lofty pinnacle to which in common with several other natural sciences energetics also proposes to raise itself in the end, to contemplate the Divine works of True Beneficence and to discern in the stately Temples of the Universe the allotted place of man.

These are some of the teachings of the radiometer which rose up before me when in an unguarded moment I asked myself the question: What change from the point of view of energy conservation would it introduce into our view of the experiment if, supposing that a force were found to actuate the vane of a radiometer, which was a direct effect of radiation, we were to sacrifice the integrity of Newton's third law of motion by assuming the existence of a new class of forces which act alone unaccompanied by any equal and opposite reaction?[1] The answer here must be that *if energy is still to be conserved* (that is to say, if we can *point out the source and destination* of all the work that is performed), *there must be a law in* these outer forces connecting them *with known physical agents* in such a manner that as much work is done upon them in any assigned change of configuration as is supplied by those physical agents in the change, and as the internal forces and other agents in the changing system also furnish by their action. (See Prof. Clerk Maxwell's definition of a "conservative system" in "Matter and Motion," p. 59, where the action of internal forces is excluded by supposing the system to return to its original configuration). In other words, we cannot suppose energy to be conserved unless we *connect the new forces by some fixed laws* with known and already determinate physical agents, and we must be content to regard the system *as non-conservative* until the necessary physical connection is assigned and introduced which will account for the free forces that we have observed, and will allow us to comprehend their action under the known laws of inanimate natural agency. This way of dealing with the work of "external forces" on a system which the new science of energy has devised, and shown to be the only one which in these cases can be generally employed, has perhaps contributed (but only by the unavoidable abstruseness and abstractness which belong to the new science itself) to invest with something of the appearance of a "phantom" and with an air of mystery, the character of force, and the laws of its operation as they have been universally studied in mechanics. But rightly regarded according to the simple principles of philosophical consistency and progress, which the new science of energy recognises in its probable extensions, there can be no doubt that it will really tend to establish more clearly than before the familiar notions of mechanics, and to open out fields of application of the time-honoured laws of motion and of force in unforeseen directions, in which their certainty and truth will continue to be felt as surely and to be described as simply now and hereafter, as they were in the days of Galileo and of Newton.

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[1] Reaction is not meant here, of course, to imply Newton's imaginary "resistance of an acceleration;" but the real active tendency of some equal opposite force only, is meant to be understood.

Newcastle-on-Tyne A. S. HERSCHEL

Faraday's "Experimental Researches"

MR. SILVANUS P. THOMPSON, of Bristol, has made, in NATURE (vol. xvii. p. 304) an inexplicable attack upon my issue of Faraday's "Experimental Researches in Electricity," 3 vols. 8vo. 1839–55, unwarranted by logic or facts.

Mr. Thompson ordered my issue, which is advertised as "*a perfect copy*" of Faraday's work, through a Bristol bookseller, to whom it was charged at the trade price of 36*s*. Mr. Thompson declined to ratify his purchase, and there the matter should have ended, as I would readily have cancelled the transaction with his agent.

Mr. Thompson says that I *profess* to supply *a perfect copy* of Faraday's "Experimental Researches," implying that my professions are deceitful. I am at a loss to understand his meaning, because the fact is that I can and do supply perfect copies.

The history of the book is as follows:—Faraday's "Experimental Researches," 3 vols., appeared in 1839–55, in 3 vols. 8vo, with plates, and in course of time two of the volumes fell out of print, which raised the market value of occasional copies to seven and eight guineas. Availing myself of the opportunity of buying from Mrs. Faraday the copyright and existing stock, I completed, by facsimile reprint, a small number of copies, as is plainly stated on the title-pages of vols 1 and 2. I alone possess the right to reprint the whole or a portion of the work.

It was at Mrs. Faraday's express wish that only such a reprint has been executed, and I was further advised to that course by eminent Fellows of the Royal Society. Mr. Thompson's innuendo of wilful deception is an infamous slander unworthy of a man of science.

I consider I deserve the thanks of all purchasers of Faraday's "Researches" for having invested my capital in the long dormant copyright of this work, and having thus put it in the power of students to obtain "perfect copies" at a moderate price.

Messrs. Taylor and Francis, the printers of the former edition, executed for me the reprint of the first two volumes (the stock of the original third volume not having been exhausted.) The original dates were preserved to show that no alterations had been made, and to preclude the notion, which Mrs. Faraday desired to avoid, that she had sanctioned a veritable new edition.

After this explanation I do not doubt that Mr. Thompson will see he has deceived himself, and I expect that he will apologise for his ill-advised attack upon my genuine and authorised re-issue, and admit that it is indeed a perfect copy of Faraday's great work. BERNARD QUARITCH

Singing in the Ears

THIS consists of two or more continuous or alternating tones originating within the ear, very faint and sounding like a tea-kettle just beginning to boil, or a distant orchestra tuning. It is heard when there is undue pressure of the circulation in the head, as after long mental application, or upon hanging the head downwards. To my ear these tones bear constant musical relations to each other, and as the phenomenon bears directly on the theory of the *mechanism* of *audition*, its verification is a matter of importance.

Will the readers of NATURE who can observe it write me what are the *intervals* of *pitch* (*i.e.* thirds, fourths, octaves, fifths, &c.) between the different tones heard together or alternating? XENOS CLARK

916, Washington Street, San Francisco, Cal.

Meteor

ABOUT 12.47 A.M. (Irish time) on Monday the 18th inst., I observed a brilliant meteor when looking north from the south side of Dublin. It resembled a bluish white ball with an apparent diameter of about one-fifth that of the moon, which was shining brightly at the time, and left behind it a continuous yellowish luminous train. When first sighted it appeared at an angular distance of about 15° from the polar star, and appeared to be in the constellation of the Dragon, about midway between the brilliant star of the constellation of Lyra and the polar star, somewhat below the line joining these constellations.

Its path was apparently a line about 5° from the vertical, and inclined from west towards east, and I lost sight of it when at an angle of 10° with the horizon by intervening buildings. Its brilliancy surpassed that of the moon, which at the time was bright enough to allow of distinguishing printed characters. It did not burst while in sight, and I heard no report.

Royal College of Science, Dublin H. HATFIELD

Eucalyptus

I have only just observed Dr. Calmy's letter in your impression of the 7th inst. (p. 283). The febrile attacks to which I alluded in NATURE (vol. xvii. p. 10) were sufficiently serious to incapacitate shepherds and stockmen for anything like continuous work for two or three weeks, and on some days the men were quite prostrated. The mosquito of which I spoke as not being banished by the presence of Eucalyptus is that species of Culex whose larval state is passed in water (the larvæ may even be seen in rain-water collected in decayed parts of trees), and I cannot call to mind a single place from which these pests were absent, trees being present. No doubt they may be carried many miles by the wind from their place of birth; but the real question is whether any species of gum so drains the land as to banish both mosquito and malaria by drying wet soil. If so, how is it that we find in Australia swamps which have existed for apparently an indefinite time, and do not look in the least likely to dry up, though the "blue" gum grows all round them, where the mosquito is rampant and malarious fever not by any means rare? I entirely agree with Dr. Calmy that the mosquito may be a "real danger to the rash traveller." One not acclimatised would suffer agonies among the mangrove swamps of Moreton Bay. I have had my own hands so paralysed by the poison that I could not close them without difficulty; and a new arrival, whom I took there on a duck-shooting expedition, was almost blinded, and became seriously ill for some days, though he was exposed to the attacks of the insects only a few hours. Whatever may be the case in Algeria or the Campagna, no one familiar with Australia will give the gum-trees there credit for having banished swamps, malaria, or mosquitos. Is not the Newfoundland mosquito of the pine forests to which Dr. Calmy alludes bred in water? ARTHUR NICOLS

February 20

Telephone Experiments

THE following experiments with the ordinary small portable telephone may interest your readers.

Experiment 1. Connect a small strip of zinc by a thin covered wire to one of the binding screws of the instrument, and connect in the same way to the other binding screw a plate of metal with a rough edge; a saw does well. Place the end of the piece of zinc in the mouth, or hold it between moist fingers. Take a shilling between the fingers of the other hand and pass it along the teeth of the saw. The sound is clearly heard in the telephone. If instead of a shilling, a sovereign or a penny be used, the result is much the same, but if a piece of zinc be substituted, the sound in the telephone, if not lost, becomes very feeble.

Experiment 2. With the apparatus as before, let a number of persons, taking hand in hand, form a chain. At one end of this chain the zinc is held, and at the other the shilling. When the saw is rubbed the sound is heard in the telephone so long as the hands are held, but on leaving go anywhere in the chain the telephone becomes silent. This experiment is successful with